

Preface

The use of natural catalysts – enzymes – for the transformation of nonnatural man-made organic compounds is not at all new: they have been used for more than 100 years, employed either as whole cells, cell organelles or isolated enzymes [1]. Certainly, the object of most of the early research was totally different from that of the present day. Thus the elucidation of biochemical pathways and enzyme mechanisms was the main reason for research several decades ago. It was mainly in the steep rise of asymmetric synthesis during the 1980s, that the enormous potential of applying natural catalysts to transform nonnatural organic compounds was recognized. What started as an academic curiosity in the late 1970s became a hot topic in synthetic organic chemistry in the 1990s. Although the early euphoria during the ‘gold rush’ in this field seems to have eased somewhat, there is still no limit to be seen for the future development of such methods, as indicated by the wave-like appearance of novel types of biocatalytic principles. As a result of this extensive research, there have been an estimated 15,000 papers published on the subject. To collate these data as a kind of ‘super-review’ would clearly be an impossible task and, furthermore, such a hypothetical book would be unpalatable for the non-expert [2–6].

The point of this textbook is to provide a *condensed* introduction to this field. It is written from an organic chemist’s viewpoint in order to encourage more ‘pure’ organic chemists of any level to take a deep breath and leap over the gap between the ‘biochemical’ sciences and ‘synthetic organic chemistry’ by persuading them to consider biocatalytic methods as an equivalent tool when they are planning the synthesis of an important target molecule. At several academic institutions this book has served as a guide for updating a dusty organic chemistry curriculum into which biochemical methods had to be incorporated. The wide repertoire of classic synthetic methods has not changed but it has been significantly widened and enriched due to the appearance of biochemical methods. This is illustrated by the fact that the proportion of papers on the asymmetric synthesis of enantiopure compounds employing biocatalytic methods has constantly risen from zero in 1970 to about 8% in 1989 [7] and it was estimated that this value is now approaching a

steady share of 15%. Certainly, biochemical methods are not superior in a general sense – they are no panacea – but they definitely represent a powerful synthetic tool to complement other methodology in modern synthetic organic chemistry.

In this book, the main stream of novel developments in biotransformations, which already had significant impact on organic chemistry, are put to the fore. Other cases, possessing great potential but still having to show their reliability, are mentioned more briefly. The literature covered by the sixth edition of this textbook extends to the end of 2010. Special credit, however, is given to some 'very old' papers as well as acknowledging the appearance of novel concepts. References are selected according to the philosophy that 'more is not always better'. Generally, I have attempted to sort out the most useful references from the pack, in order to avoid writing a book with the charm of a telephone directory! Thus, special emphasis is placed on reviews and books, which are often mentioned during the early paragraphs of each chapter to facilitate rapid access to a specific field if desired.

The first edition of this book appeared in September 1992 and was predominantly composed as a monograph. It was not only well received by researchers in the field but also served as a basis for courses in biotransformations worldwide. In the second, completely revised edition, emphasis was laid on didactic aspects in order to provide the first textbook on this topic in 1995. Its great success has led to the demand for updated versions with emphasis on new trends and developments. In this context, novel techniques – dynamic resolution, stereoinversion, and enantioconvergent processes – were incorporated, in addition to the basic rules for the handling of biocatalysts.

My growing experience of teaching the use of biotransformations at several universities and research institutions around the world has enabled me to modify the text of this sixth edition so as to facilitate a deeper understanding of the principles, not to mention the correction of errors, which escaped my attention during previous editions. I am grateful to numerous unnamed students for pointing them out and for raising questions and to my old Macintosh IIfx, which reliably served for 14 years without crashing.

I wish to express my deep gratitude to Stanley M. Roberts (UK) for undergoing the laborious task of correcting the manuscripts of the early editions of this book, for raising numerous questions and for helpful comments. Special thanks also go to M. Müller, U. Bornscheuer, W.-D. Fessner, A. Liese (Germany), N.J. Turner (UK), J.-E. Bäckvall (Sweden), R. Kazlauskas (USA), B. Nidetzky, and W. Kroutil (Graz) for their helpful hints and discussions. This revised edition would not have been possible without the great assistance of A. Preisz and B. Mautner.

I shall certainly be pleased to receive comments, suggestions, and criticism from readers for incorporation in future editions.

Graz, Austria
Spring 2011

Kurt Faber

References

1. For the history of biotransformations see:

Needleman SG (1990) The archeology of enzymology. In: Abramowicz D (ed) *Biocatalysis*, Van Nostrand Reinhold, New York, pp 1–24

Roberts SM, Turner NJ, Willetts AJ, Turner MK (1995) *Introduction to Biocatalysis Using Enzymes and Micro-organisms*, Cambridge University Press, Cambridge, pp 1–33

2. For conference proceedings see:

Porter R, Clark S (eds) (1984) *Enzymes in Organic Synthesis*, Ciba Foundation Symposium 111, Pitman, London

Tramper J, van der Plas HC, Linko P (eds) (1985) *Biocatalysis in Organic Synthesis*, Elsevier, Amsterdam

Schneider MP (ed) (1986) *Enzymes as Catalysts in Organic Synthesis*, NATO ASI Series C, vol 178, Reidel, Dordrecht

Laane C, Tramper J, Lilly MD (eds) (1987) *Biocatalysis in Organic Media*, Elsevier, Amsterdam

Whitaker JR, Sonnet PE (eds) (1989) *Biocatalysis in Agricultural Biotechnology*, ACS Symposium Series, vol 389, Washington

Copping LG, Martin R, Pickett JA, Bucke C, Bunch AW (eds) (1990) *Opportunities in Biotransformations*, Elsevier, London

Abramowicz D (ed) (1990) *Biocatalysis*, Van Nostrand Reinhold, New York

Servi S (ed) (1992) *Microbial Reagents in Organic Synthesis*, NATO ASI Series C, vol 381, Kluwer Academic Publishers, Dordrecht

Tramper J, Vermue MH, Beeftink HH, von Stockar U (eds) (1992) *Biocatalysis in Non-conventional Media*, Progress in Biotechnology, vol 8, Elsevier, Amsterdam

3. For monographs see:

Jones JB, Sih CJ, Perlman D (eds) (1976) *Applications of Biochemical Systems in Organic Chemistry*, part I and II, Wiley, New York

Davies HG, Green RH, Kelly DR, Roberts SM (1989) *Biotransformations in Preparative Organic Chemistry*, Academic Press, London

Halgas J (1992) *Biocatalysts in Organic Synthesis*, Studies in Organic Chemistry, vol 46, Elsevier, Amsterdam

Poppe L, Novak L (1992) *Selective Biocatalysis*, Verlag Chemie, Weinheim

Cabral JMS, Best D, Boross L, Tramper J (eds) (1994) *Applied Biocatalysis*, Harwood, Chur

Roberts SM, Turner NJ, Willetts AJ, Turner MK (1995) *Introduction to Biocatalysis Using Enzymes and Micro-organisms*, Cambridge University Press, Cambridge

Bornscheuer UT, Kazlauskas RJ (2006) *Hydrolases for Organic Synthesis*, Wiley-VCH, Weinheim

Bommarius AS, Riebel B (2004) *Biocatalysis, Fundamentals and Applications*, Wiley-VCH, Weinheim

Grunwald P (2009) *Biocatalysis, Biochemical Fundamentals and Applications*, Imperial College Press, London

4. For reference books see:

Kieslich K (1976) *Microbial Transformations of Non-Steroid Cyclic Compounds*, Thieme, Stuttgart

Drauz K, Waldmann H (eds) (2002) *Enzyme Catalysis in Organic Synthesis*, 2nd edn, 3 vols, Wiley-VCH, Weinheim

Liese A, Seelbach K, Wandrey C (eds) (2006) *Industrial Biotransformations*, 2nd edn, Wiley-VCH, Weinheim

5. For collections of reviews see:

Koskinen AMP, Klivanov AM (eds) (1996) *Enzymatic Reactions in Organic Media*, Blackie Academic & Professional, London

Collins, AN, Sheldrake GN, Crosby J (eds) (1992) *Chirality in Industry*, Wiley, Chichester

Collins, AN, Sheldrake GN, Crosby J (eds) (1997) *Chirality in Industry II*, Wiley, Chichester

- Scheper T (ed) (1999) *New Enzymes for Organic Synthesis*, Adv Biochem Eng Biotechnol, vol 58, Springer, Berlin, Heidelberg, New York
- Fessner W-D (ed) (1999) *Biocatalysis – from Discovery to Application*, Topics Curr Chem, vol 200, Springer, Berlin, Heidelberg, New York
6. For a collection of preparative procedures see:
- Roberts, S M (1999) *Biocatalysts for Fine Chemicals Synthesis*, Wiley, Chichester
- Whittall J, Sutton PW (eds) (2010) *Practical Methods for Biocatalysis and Biotransformations*, Wiley, Chichester
- Jeromin GE, Bertau M (2005) *Bioorganikum*, Wiley-VCH, Weinheim
7. For the application of biotransformations to stereoselective synthesis see:
- Dordick JS (ed) (1991) *Biocatalysts for Industry*, Plenum Press, New York
- Crosby J (1992) *Chirality in Industry – An Overview*. In: Collins, AN, Sheldrake GN, Crosby J (eds) *Chirality in Industry*, Wiley, Chichester, pp 1–66
- Patel RN (ed) (2000) *Stereoselective Biocatalysis*, Marcel Dekker, New York
- Patel RN (ed) (2007) *Biocatalysis in the Pharmaceutical and Biotechnology Industries*, CRC Press, Boca Raton